

University of Colorado, Boulder
CU Scholar

Undergraduate Honors Theses

Honors Program

Spring 2010

Mental Imagery, Observational Learning and External Focus in Experts

Annette Grotheer

University of Colorado Boulder

Follow this and additional works at: http://scholar.colorado.edu/honr_theses

Recommended Citation

Grotheer, Annette, "Mental Imagery, Observational Learning and External Focus in Experts" (2010). *Undergraduate Honors Theses*. Paper 248.

This Thesis is brought to you for free and open access by Honors Program at CU Scholar. It has been accepted for inclusion in Undergraduate Honors Theses by an authorized administrator of CU Scholar. For more information, please contact cuscholaradmin@colorado.edu.

Mental Imagery, Observational Learning and External Focus in Experts

Annette Grotheer

Advisor Dr. Healy

Department of Psychology and Neuroscience,

University of Colorado Boulder

4/1/10

Committee Members:

Dr. Kristin Lopez, Department of Integrated Physiology

Dr. Mark Whisman, Department of Psychology and Neuroscience

Dr. Alice Healy, Department of Psychology and Neuroscience (Advisor)

Abstract

The current study examined the possible additive benefits of focus of attention (FOA) on observational learning, mental imagery, and physical practice. Utilizing a full-body multiphase physical task allowed us to examine the influence of each of these effects on overall athletic performance. Subjects were limited to experts in the selected long-jump task. Internal and external foci of attention were compared using a mixed factorial analysis of variance. A difference was found reflecting longer distances jumped for internal FOA than for external FOA. This effect, however, was attributed to unintended differences between the two groups due to their level of expertise. Normalized data corrected for this problem and revealed no effect of FOA. Although FOA did not influence speed or distance overall, an external FOA produced a pattern of higher levels of improvement following physical practice when compared to internal FOA. Furthermore, both analyses yielded a significant effect of condition, reflecting longer distances following physical practice than following mental or observational practice.

Keywords: focus of attention, observational learning, mental imagery, expertise, athletic performance

Mental Representation, Observational Learning and External Focus in Experts

The modes of skill acquisition utilized by individuals have been of much interest throughout the years. As society advances, and the demands on increasing an individual's aptitude for specified tasks increase, so do the standards applied to training methods that aid in the acquisition of said skills. For teaching and learning processes to aid the rapidly increasing demands on expertise, methodologies that serve to improve skill learning must be improved. Although it has been demonstrated that repetition is one such method that improves skill acquisition (i.e., the time it takes to learn a skill), further alterations may be implemented during the learning process to cultivate stronger performance in the acquisition and performance of motor tasks. Several alterations center on transitioning skill acquisition processes from declarative ones to more procedural ones earlier in the learning process. As skills move from a more declarative to a procedural mode, mental load decreases and allows for more effortless action (Haider & Frensch, 1996). Several adaptations of practice methodologies may encourage this proceduralization process, in turn increasing skill acquisition and performance.

Focus of Attention

Focus of attention (FOA) is one such method; by delineating a specified FOA, differentiated levels of motor skill performance can be observed. For example, focus may be directed toward an external or internal aspect of a task; an external focus encompasses the results of an action, whereas an internal focus centers on the specified movements performed while executing a given task. When contrasting these two foci, an external focus is favored because it not only increases accuracy, but also increases movement efficiency. By utilizing a dart throwing task coupled with EMG data, Lohse, Sherwood, and Healy (2010) discerned that an

external FOA decreased the EMG activity in the triceps brachii, suggesting improved movement economy. Further, an external FOA produced less absolute error when compared to an internal FOA. In fact, there is a large body of evidence suggesting that instructions engendering the use of an external FOA largely improve performance of object manipulation tasks. For example, accuracy of golf swings in amateurs (Wulf, Lauterbach, & Toole, 1999) and experts (Wulf & Su, 2007), and free-throw accuracy in basketball (Zachry, Wulf, Mercer, & Bezodis, 2005) were improved due to an external FOA.

Though an external FOA lends robust findings that attest to the levels of improvement elicited in object manipulation tasks, it is also important to look at an external FOA's influence on motor skill performance, specifically when applied to whole body movement tasks. Such whole body movements (e.g., as standing long-jump and vertical height test) are often used to quantify an athlete's general athletic skill. By looking at FOA's influence on whole body tasks, we can better analyze its effects on motor skills, and more specifically, athletic skill improvement.

Porter, Ostrowski, Nolan, and Will (2010) have demonstrated that levels of improvement similar to those seen in object manipulation tasks are seen when applying FOA to a full body motor task. In this study, subjects were told to jump as far as possible while "focus[ing] [their] attention on extending [their] knees as rapidly as possible . . . [or] on focus[ing] [their] attention on jumping as far past the start line as possible" (p. 1748). They saw significantly farther distances jumped in the external group, the one focused on jumping as far past the start line as possible, compared to the internal focus group, which was focused on extending their knees as quickly as possible. This level of improved skill performance indicates that FOA was influential in the improvement of a full body motor skill. This study, however, utilized novice individuals;

any participants with prior jump training were excluded. For this parameter, looking at the positive influence of FOA on the performance of an athletic skill or motor task may be better demonstrated with experts than with novices. We postulate that not only are experts the individuals who would benefit the most from more specified training to refine skills, but they should also profit the most from pre-motor training tactics (e.g., FOA). Experts have more exposure to the domain specific skills and knowledge associated with a task and are able to access these chunks of information with more ease than a novice (Simon & Chase, 1973). For example, if they have performed a task before, experts may easily access fundamental movements and skills associated with a task, allowing them to better employ a specified FOA. Further, if a high level of conscious attention is required for task completion, it "impairs automatic mechanisms in the body underlying skilled performance" (Healy, in press, p. 5). Experts already possess this innate relationship with skill performance, and FOA may serve to further amplify this relationship. Therefore, in this study, we examine the effects of FOA on expert performance in the hopes that experts possess a higher capability to implement instructions associated with FOA, allowing them to benefit from this methodology more than novices.

Mental Imagery

Although FOA has been studied in the context of performing motor tasks, little data have been collected when applying this method in combination with other pre-motor training methods, training that occurs before physical movement takes place. We hope to test whether pre-motor methods of practice, which have shown to improve skill learning, would benefit from the addition of FOA; mental imagery is one of the pre-motor forms of practice we believe would benefit from the addition of FOA. In isolation, mental imagery has been suggested to push the

boundaries of skill learning when compared to physical practice. By mentally representing a task, individuals are consequently activating several of the pathways accessed during the physical performance of an activity (Wohldmann, Healy, & Bourne, 2007). Wohldmann et al.'s (2007) study substantiates that mental imagery and physical practice have advantages in regards to repetition priming, or in their study, the typing of previously performed numbers. Furthermore, practice with mental imagery was found to be resistant to decay, allowing practiced numbers to be typed faster than novel ones despite a 3-month delay. This finding suggests that both imagined typing and physical typing strengthen critical representations that allow increased skill acquisition and retention.

A follow up study by Woldman, Healy, and Bourne (2008) also illuminated that beyond the increases in motor skill performance, mental imagery may also reduce the effects of forgetting. After a delay, when results were examined, participants whom were part of the mental imagery practice group showed lower levels of forgetting; their scores were significantly closer to those of their performance at initial testing. This finding suggests that mental imagery utilizes said critical representations in order to further strengthen an individual's ability to access and use stored representations of tasks.

Although these studies demonstrate a definite increase in skill acquisition, one that rivals that of physical practice, other studies have stated that mental imagery cannot produce results equal to physical practice especially with motor tasks; it is however, better than no practice at all. They have further gone on to say that mental practice is most beneficial when used in combination with physical practice (Schuster et al., 2011, Sheikh & Korn, 1994). For this reason, once again, it can be hypothesized that the factor of expertise is highly influential on the level of skill improvement observed.

Expertise

Research has shown that mental rehearsal and external focus have individually produced increased levels of accuracy, skill acquisition, transferability, resistance to interference, and efficiency in task execution. Mortensen (2011) combined mental rehearsal and external focus to examine if these factors, in combination, could lead to further improvement of motor skill performance. He found that an external focus decreased variability in accuracy for both physical and mental practice variables. Although an increase in performance was seen after mental rehearsal was utilized, no significant finding was found for this measure. One flaw of this study may lie in the use of a random sample composed primarily of novice individuals.

Expertise may be a significant factor affecting pre-motor practice, allowing more experienced individuals to utilize methodologies such as mental imagery and observational learning to their full potential. Several factors may influence experts' capacity to utilize information in specified domains and allow them to apply their knowledge more aptly. It is theorized that experts are able to store and access larger chunks of information than novices. By storing larger chunks, they are able to lower their cognitive load, in turn increasing their ability to access information and perform multiple tasks simultaneously. This concept of chunking is also thought to allow experts to associate such chunks with more hypothetical representations of a task. For example, chess players have continuously proven to associate hypothetical moves, which they have stored in their memory, with patterns of chess pieces seen in an ongoing game (Ericsson, Charness, Feltovich, & Hoffman, 2006). This finding demonstrates that via chunking, experts are more easily able to access representations of motor skills or movements that they have associated with their domain specific knowledge (Simon & Chase, 1973). Novices are assumed to lack sufficient exposure to specified tasks that would allow them to achieve these

kinds of representational associations. Because experts have a stronger grasp on more hypothetical representations of motor skills, it may allow them to better utilize pre-motor learning methodologies and engender larger effect sizes than Mortenson (2011) was able to produce.

Another aspect considered to be pivotal to the usage of expert knowledge is the transition of many aspects of tasks to automatic processing. This progression allows experts to use their knowledge more powerfully by increasing their “capability for controlled management of memory and knowledge application” (Perfetti & Lesgold, 1977). An increased level of automaticity, in combination with memory and knowledge application, may allow our experts to access fundamental cues from memory during pre-motor practice, which will facilitate greater levels of improvement in motor task performance. Because verbal instructions are utilized in our study, this ability to manage knowledge application may increase the efficacy of each type of pre-motor practice; better application of instructions has the potential to actualize superior usage of instructions which is pivotal in pre-motor practice.

Specific studies have utilized such postulations regarding expert use of premotor practice in their research to demonstrate the benefits of expertise on mental imagery practices. Prior research has shown that individuals familiar with a specific task benefited more from the effects of mental practice than novices (Mulder, Zijlstra, Zijlstra, & Hochstenbach, 2003). Furthermore, Orlick and Partington (1988) concluded that “attentional focus and the quality and control of performance imagery were the most statistically significant athlete skills directly related to high level performance at the Olympic Games” (p. 129). Therefore the use of experts may be a significant factor when attempting to produce significant increases of skill performance in association with mental imagery, FOA, and observational learning.

Observational Learning

Observational learning is another important form of practice to examine in conjunction with a high level of expertise. Observational learning has significant advantages “over practice-only control conditions” (Ashford, Bennet, & Davids, 2006), and data suggest that when people observe an action, the same areas of the brain are activated as when individuals imagine and execute mirror actions (Decety et al. 1997; Buccino et al., 2001). These types of neural associations and advantages may be permitted because of the nature of observation; when models presented are highly representative of real world situations (Ericsson et al., 2006), they may be more easily translated to stored motor sequences than when information or instruction are provided in a different framework. In addition, by using visual cues, the information processing stage is accelerated to long-term memory when compared to the process utilized to ascertain information from written or verbal instructions (Craik, & Lockhart, 1972). This fact, in combination with the Haider and Frensch’s (1996) regarding early proceduralization, suggests that utilizing this more procedural, or mental load reducing method of practice may promote increased athletic performance. Although the use of observational learning to increase performance has been substantiated utilizing novel tasks, it will be beneficial to apply this methodology to expert levels of performance. Thomas, Gallagher, and Lowry (2003) have ascertained that higher levels of differentiation in performance are found when comparing novice and expert subjects and their utilization of observational learning. Considering the encouraging effects that the use of observational learning among experts may afford, it is important to further examine this form of pre-motor learning and its capacity to increase performance, especially in conjunction with FOA.

Furthermore, the use of highly representative observational models is especially effective for serial tasks (Ashford et al., 2006). Combining expertise with a serial motor task allows for an entirely new outlook on observational learning. We propose this fusion will moreover engender learning about the intricacies and benefits of an observational learning model.

Methods

Subjects

Individuals with competitive long-jump experience were selected because of their expertise with the experimental task. A sample of 19 individuals was selected on a volunteer basis from high school, college, and post college populations. Only subjects with training in long-jump within the past 2 years were permitted to participate. Posters were distributed by track team coaches and were placed in athletic centers to advertise the study. Subjects were compensated with a \$25 dollar gift card for 2 hours of their time.

Design

Six combinations of variables were tested using a mixed factorial design; this design allows the examination of both internal and external focus of attention and their effects on mental rehearsal, observational rehearsal, and physical rehearsal. This format also permits us to determine the most efficient combination of factors amongst those tested. Further, because of the small number of experts available, type of practice served as a within subjects variable, allowing us to limit variance between trials and to increase statistical power in our analyses. Focus of attention served as a between-subjects variable; therefore, each subject utilized either an internal or external FOA and preformed trials using mental rehearsal, observational rehearsal, and physical rehearsal simultaneously using the type of FOA they were assigned throughout all trials. Counterbalancing the order that each type of practice was performed (i.e., mental, observational,

or physical) limited practice effects. To ensure complete counterbalancing, we assigned subjects to one of the six possible practice orders, which ensured each type of practice was done in every possible permutation. For example, in one order physical practice (P) was performed first, followed by observational practice (O), and finishing with mental practice (M). We utilized the orders POM, OPM, OMP, PMO, MOP, and MPO.

Procedure

An official runway was used. Distances jumped and speeds of runway approaches were recorded to examine improvement in subjects' performance. Distance was measured in inches using a tape measure based on the first imprint made in the sand pit. Only the imprint closest to the edge of the runway was recorded. Speed of the approach was timed in seconds with a stop watch. Subjects participated in a baseline trial where they executed two jumps with no specified instructions in order to determine their initial baseline. The average of these two jumps was used as a point of comparison when determining skill improvement. Participants then performed three blocks of trials. Each block consisted of eight practice jumps performed mentally, physically or observationally. After the practice phase in each given block was a test phase where two final jumps were recorded. Each of the three blocks adhered to the same procedure, permitting each form of practice to be examined in the same way. See Figure 1.

Results

Though we intended to fully counterbalance the orders that subjects were tested, our final analyses are based on $N=19$; therefore the data are not fully counterbalanced. The use of a mixed factorial analysis of variance (ANOVA) revealed results different from what we expected. There were no significant effects when looking at the speed of our subjects. For distance, we saw a main effect of FOA, $F(1, 17) = 5.456, p = .032$, suggesting that an internal FOA ($M = 195$ in.)

improved subjects' performance more than did an external FOA ($M = 170$ in.). A main effect for condition was also found for distance, $F(3,51) = 3.093$, $p = .035$. Subjects jumped farther following physical practice ($M = 187$ in.) than following observational practice ($M = 179$ in.) or mental practice ($M = 178$ in.), with the baseline $M = 185$ in. See Figure 2. We theorized that the main effect of FOA may have been a result of the variance in skill levels seen in different groups (the internal FOA group contained a subject participating in Olympic trials).

Therefore we normalized the data allowing us to base analysis on the proportion of improvement each subject demonstrated compared to the baseline. In order to normalize our time data, we used the following formula: (baseline approach times - experimental condition approach times)/baseline approach times. For distances jumped data, we utilized this formula: (experimental condition jump distance - baseline distance)/baseline distance. This calculation allowed us to see overall improvement where faster times (times less than baseline) are considered improvement and farther distances (distances larger than baseline) are considered to show improvement. Using these modified data we eliminated any effects involving FOA for distance, but there was still a significant main effect of condition, $F(2,34) = 3.767$, $p = .0333$, with physical practice (.015) eliciting a larger level of improvement in subjects' distances jumped than either mental practice (-.040) or observational practice (-.028). Also, for distance, the interaction of condition by FOA approached significance, $F(2, 34) = 1.768$, $p = .186$, where those performing physical practice utilizing an external FOA yielded the most improvement; see Figure 3. Effects for time remained nonsignificant.

Though external FOA showed greater levels of improvement in subjects' jump distances, the overall trend for both time and distance was negative, showing a decrease in performance in test jumps compared to baseline jumps. To eliminate the possibility of a fatigue effect, we

analyzed block x FOA using the data from our practice condition (8 physical practice jumps) for both time and distance. Here time showed no significant change over block, but overall subjects in both FOA groups were running slower as trials progressed. We did see that distance improved somewhat by block although this difference was not significant, $F(7, 112) = 1.527, p = .1652$. See Figure 4.

Discussion

We found that long-jump distance improved following physical practice, but not following either mental or observational practice. This result might be due to the fact that there was no physical practice coupled with the mental or observational practice in this experiment. Thus, these findings imply that for mental or observational practice to be effective, it must be combined with physical practice (e.g., Schuster et al., 2011; Sheikh & Korn, 1994; Wohldmann et al., 2007).

Several limitations affected the outcome of our study. First of all, the limited number of experts that we were able to recruit highly influenced our results. Similarly, the number of subjects influenced our ability to fully counterbalance our practice orders. With such limitations, we were able to make limited inferences.

Time constraints also limited the study outcome. Subjects' performance of only two baseline jumps gave us a very limited knowledge of subjects' initial abilities. To improve this limitation, we suggest that further studies of experts utilize a re-familiarization period (many subjects had several years of latency in their long-jump activities) as well as a four- or five-jump baseline assessment. This initial preparation phase would further decrease variance of jumps and speeds in the practice and test phases, analogously reducing numbers of scratches and increasing analyzable data. The same factor can account for variance in our test phase results when

compared to baseline. Because of the limited number of practice jumps performed, it is possible that a weaker level of improvement developed. Many studies used upwards of 30 practice trials before testing, providing a stronger possibility that practice methods are used in testing.

Further analysis of data would reveal whether a significantly different proportion of external vs. internal attenders scratched, allowing us to quantify whether subjects used their assigned FOA (Gray, 2004). In this manipulation check, internal attenders would have a higher level of accuracy with decreased performance.

Additionally, an analysis of estimated scratch difference data may allow more exact determination of results. During each trial, if a subject scratched, an estimated distance of scratch was recorded. By subtracting these numbers from initial data, and analyzing this new data set, we may see changes in study outcome.

References

- Ashford, D., Bennet, S.J., & Davids, K. (2006). Observational modeling effects for movement dynamics and movement outcome measure across differing task constraints: A meta-analysis. *Journal of Motor Behavior*, 38, 185-205.
- Buccino, G., Binkosfski, F., Fink, G. R., Fadiga, L., Foggassi, L., Gallese, R. J., . . . Freund, H. J. (2001). Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience*, 13, 400-404.
- Craik, F.I.M., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behaviour*, 11, 671-684.
- Decety, J., Grezes, J., Costes, N., Perani, D., Jeannerod, M., Procyk, E., . . . Fazio, F. (1997). Brain activity during observation of actions: Influence of action content and subject's strategy. *Brain*. 120, 1763-1777.
- Ericsson, K. A., Charness, N., Feltovich, J. P., & Hoffman, R. R. (Eds.). (2006). *The Cambridge handbook of expertise and expert performance*. New York: Cambridge University Press.
- Gray, R. (2004). Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *Journal of Experimental Psychology*, 10, 42-54.
- Healy, A. F. (in press). Skill learning, enhancement of. In H. Pashler (Ed.), *Encyclopedia of the mind*. Thousand Oaks, CA: Sage.
- Haider, H., & Frensch, P.A. (1996). The role of information reduction in skill acquisition. *Cognitive Psychology*, 30, 304-337.

- Lohse, K. R., Sherwood, D. E., & Healy, A. F. (2010). How changing the focus of attention affects performance, kinematics, and electromyography in dart throwing. *Human Movement Science, 29*, 542-555.
- Mortenson, D. L. (2011). *Mental attention: Improving motor imagery by adding focus*. Unpublished senior honors thesis, University of Colorado, Boulder.
- Mulder, T., Zijilstra, S., Zijilstra, W., & Hochstenbach, J. (2003) The role of motor imagery in learning a totally novel movement. *Experimental Brain Research, 154*, 211-217.
- Orlick, T., & Partington, J. (1988). Mental links to excellence. *The Sport Psychologist, 2*, 105-130.
- Perfetti, C. A., & Lesgold, A. M. (1977). Coding and comprehension in skilled learning. In K. A. Ericsson, N. Charness, J. P. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (p. 54). New York: Cambridge University Press.
- Porter, J. M., Ostrowski, E. J., Nolan, R. P., & Will, F. W. (2010). Standing long-jump performance is enhanced when using an external focus of attention. *Journal of Strength and Conditioning Research, 24*, 1746-50.
- Schuster, C., Hilfiker, R., Amft, O., Scheidhauer, A., Andrews, B., Butler, J., & ... Ettlin, T. (2011). Best practice for motor imagery: a systematic literature review on motor imagery training elements in five different disciplines. *BMC Medicine, 9*, 75-109.
- Sheikh, A. A., Korn, E. R. (1994). *Imagery in sports and physical performance*. New York: Bayewood Publishing Company.
- Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61*, 394-403.

- Thomas, J. R. Gallagher, J., & Lowry, J. (2003). Meta analysis of motor expertise. Invited Motor Development Scholar Address presented at the North American Society for the Psychology of Sport and Physical Activity Conference. NASPSPA: Savannah, GA,
- Wohldmann, E. L., Healy, A. F., & Bourne, L. E., Jr. (2007). Pushing the limits of imagination: Mental practice for learning sequences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33, 254-61.
- Wohldmann, E. L., Healy, A. F., & Bourne, L. E., Jr. (2008). A mental practice superiority effect: Less Retroactive Interference and more transfer than physical practice. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34, 823-833.
- Wulf, G., Lauterbach, B., & Toole, T. (1999). Learning advantages of an external focus of attention in golf. *Research Quarterly for Exercise & Sport*, 70, 120-126.
- Wulf, G., & Su, J. (2007). An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise & Sport*, 78, 384-389.
- Zachry, T., Wulf, G., Mercer, J., & Bezodis, N. (2005). Increased movement accuracy and reduced EMG activity as a result of adopting an external focus of attention. *Brain Research Bulletin*, 67, 304-309.

	Internal FOA (Group 1)	External FOA (Group 2)
Observational Rehearsal	During the practice phase, subjects observed a teammate, who was matched by FOA, while focusing on the movement of their partner's legs during both the approach and jump.	During the practice phase, subjects observed a teammate, who was matched by FOA, while focusing on speed during the approach and where they landed in the sand pit.
Physical Rehearsal	During the practice phase, subjects performed an actual jump while focusing on the movement of their legs during both the approach and jump.	During the practice phase, subjects performed an actual jump while focusing on speed during the approach and where they landed in the sand pit.
Mental Rehearsal	During the practice phase, subjects visualized themselves performing a jump while focusing on the movement of their legs during both the approach and jump.	During the practice phase, subjects performed an actual jump while focusing on speed during the approach and where they landed in the sand pit.

Figure 1. Experimental Groups. This figure explains each combination of variables examined.

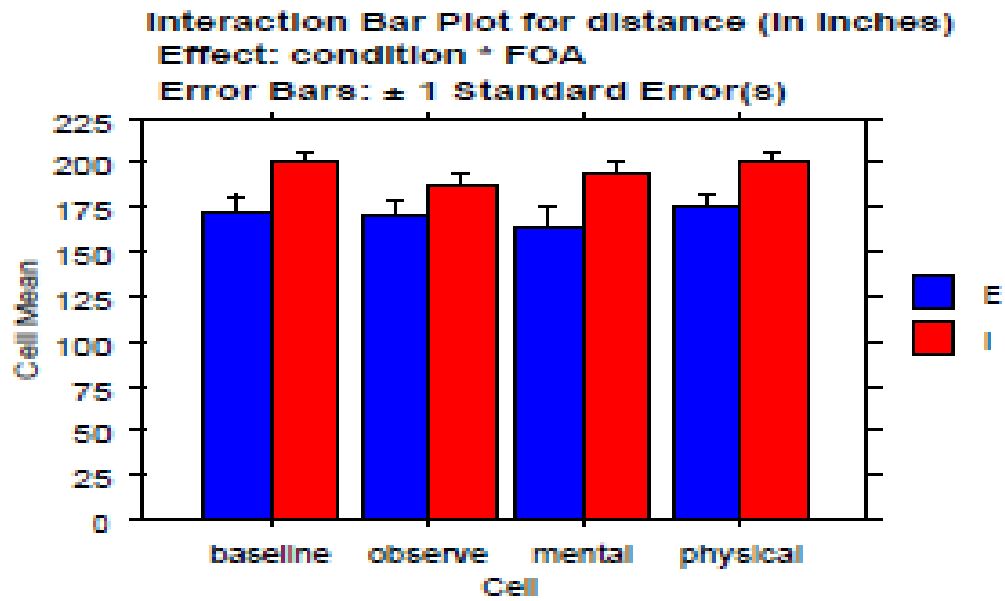


Figure 2. Mean distance for non-normalized data. The Y axis shows distances jumped in inches; the X axis shows the baseline and the three conditions; the blue bars are for external focus, and the red bars are for internal focus.

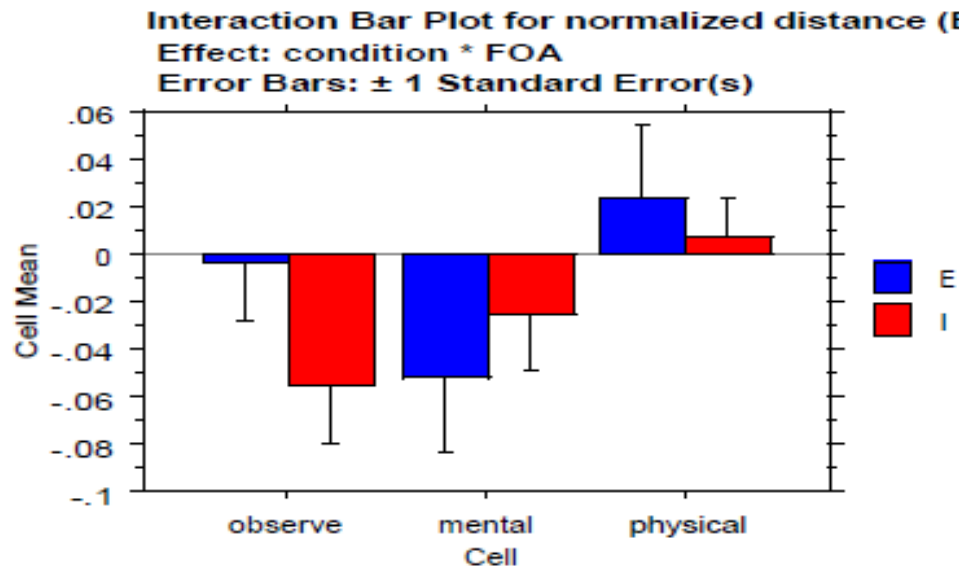


Figure 3. Mean normalized distance. The Y axis shows normalized distances jumped; the X axis shows the three conditions; the blue bars are for external focus, and the red bars are for internal focus.

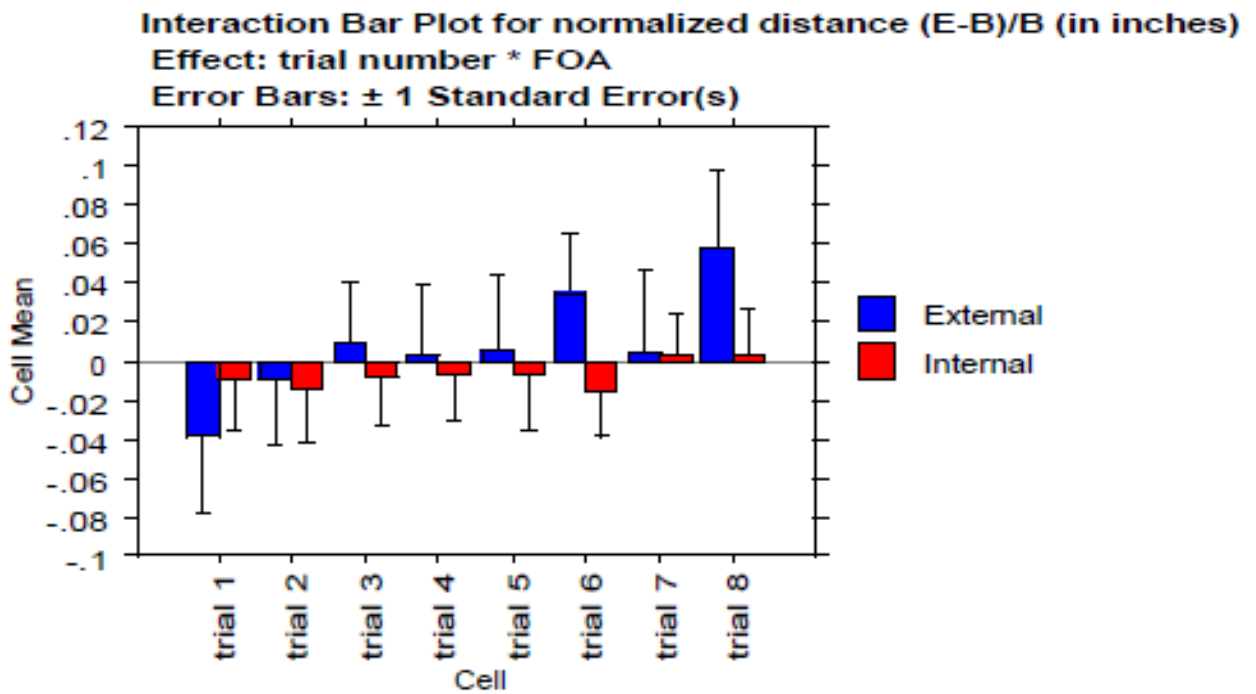


Figure 4. Mean normalized distance during practice for the physical practice condition. The Y axis shows normalized distances jumped; the X axis shows trial numbers; the blue bars are for external focus, and the red bars are for internal focus.